# The Vision on Future TD-SCDMA

LIU Guangyi, ZHANG Jianhua, ZHANG Ping
WTI Institute, Beijing University of Posts&Telecommunications,
P.O. Box 92, No. 10, XiTuCheng Road, HaiDian District, Beijing, P.R.China,100876
Email：lgy@buptnet.edu.cn

***Abstract*-As the increasing demand for mobile data service, 2Mbps peak data rate of TD-SCDMA will not fulfill the user's need any more in several years. While the new B3G system to provide high data rate service is still not available until 2010, the current TD-SCDMA must be enhanced to fulfill the requirement of the new service. As one 3G standard accepted by ITU and 3GPP, TD-SCDMA should also be enhanced and improved as WCDMA and CDMA2000. In this paper, the future vision on the evolution and enhancement of TD-SCDMA is given out. According to our research, the smooth evolution from TD-SCDMA to B3G TDD can be summarized as five phases: TSM, LCR, HDR, B3G TDD and after 4G; while the research and development on TD-SCDMA enhancement can be done from the aspects of Generalized Distributed Antenna Arrays (GDAA), Dynamical Radio Resource Management, MIMO, AMC, etc. Finally, a High Data Rate proposal for TD-SCDMA is presented as a reference for future research on this topic, and the peak data rate is 3.96Mbps.**

**Key Words: DCA, MIMO, AMC, TD-SCDMA, evolution and enhancement, GDAA**

## I. INTRODUCTION

TD-SCDMA was proposed by CATT (Chinese Academy of Telecommunication Technology) in 1998 on behalf of China, and approved by ITU as one popular international 3G standards in May, 2000, and accepted by 3GPP as one of the 3G standards in March, 2001 [1]. Compared to the other 3G standards, TD-SCDMA is a fully new system, which adopts a series of newest techniques, such as TDD, synchronous CDMA, smart antenna, joint detection, software radio, baton handover and dynamical channel allocation, and son on. Its obvious advantages and excellent performance can be shown as following:

1. Unpaired frequency band is required and it has high capability to deploy a cellular network. The minimum frequency bandwidth of TD-SCDMA is 1.6MHz. 5 MHz frequency band can support 3 carriers to deploy a cellular network to provide mobile service.

2. TD-SCDMA has the highest theoretical spectrum efficiency. For smart antenna, joint detection, and synchronous CDMA, the MAI is minimized, and the inter-cell interference is compressed, the capacity is improved much more than the other systems. The baton handover can decrease the handover delay, improve the handover performance and guarantee the QoS. As TDD mode combined with DCA, TD-SCDMA is very suitable for asymmetrical data service and very flexible to utilize the spectrum, and lead to higher capacity. All these newest techniques make the spectrum efficiency of TD-SCDMA theoretically highest in 3G standards.

3. TD-SCDMA system has the lowest cost. Benefit from software radio structure, low chip rate CDMA, and TDD mode, the cost of TD-SCDMA BTS and BSC for every subscriber is lower than that of GSM by 30% [2]. The update of the base station is very simple, and it is flexible to adopt new feature and techniques.

4. TD-SCDMA can be deployed in all kinds of environments required by ITU.

However, TD-SCDMA also has the following possible problems for its features.

### A. Coverage problem.

The coverage radius of TD-SCDMA is mainly decided by two factors: one is the transmit power and the reception sensitivity, and the other is the length of the guard period. For the smart antenna and joint detection, the requirement on the transmit power and reception sensitivity of TD-SCDMA is loosened. As a TDD system, the guard period is required between the uplink and downlink time slot. So the coverage radius of TD-SCDMA is limited by the length of the guard period. To avoid the interference between the uplink synchronization and downlink synchronization, the maximum coverage radius of TD-SCDMA should be less than 11.25 Km. Larger coverage radius should sacrifice some capacity [3].

### B. High mobility problem.

The highest mobile speed required for TDD is 120Km/h by ITU, while it is 500Km/h for FDD. For discontinuous transmission, the fast fading has more serious impact on TDD system, so it's a challenge for TD-SCDMA to support high mobility.

### C. The evolution and industrializing procedure falls behind the other 3G standards.

For the economic capability and amount of investment of TD-SCDMA alliance is far less than that of WCDMA and CDMA2000 alliance, the evolution and enhancement of TD-SCDMA has fallen behind the other 3G standards. Most effort of TD-SCDMA standard is focused on product development and testing, little work has been done on the evolution and enhancement of the standards.

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Most of the standardization work is just follow that of WCDMA in 3GPP.

In this paper, the future vision on the evolution and enhancement of TD-SCDMA is presented, and the possible techniques for the enhancement on TD-SCDMA are shown. Furthermore, a High Data Rate (HDR) scheme based on MIMO Eigen beamforming is proposed as a reference for future research on this topic. This paper is organized as follow. The status of WCDMA, CDMA2000 and B3G is roughly summarized and the necessity of the enhancement and evolution on TD-SCDMA is shown in section II and the evolution path is given in Section III; In Section IV, the possible technique and scheme for TD-SCDMA enhancement and evolution is given out and a HDR proposal is presented as references for further research on this topic.

## II. NECESSITY OF EVOLUTION AND ENHANCEMENT FOR TD-SCDMA

As the development of communication technique and the service demand, the mobile subscribers require higher and higher mobile data rate, while the available frequency band becomes rare and rare. So the future mobile system is required to provide high data rate, high mobility and high spectrum efficiency. According to the research result of ITU, future need for data rate is predicted as follow:

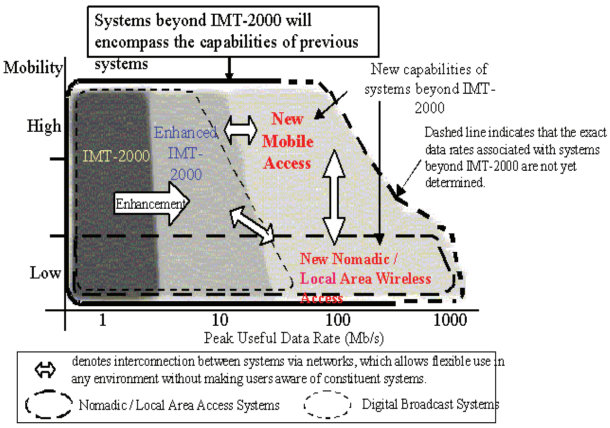


Fig 1 the trend of future mobile data rate from ITU WP8F

According to the schedule of ITU, the B3G commercial system will be deployed in 2010. Before that, the requirement from the subscribers should be fulfilled by the current 3G systems and WLAN. Although WLAN can provide much higher data rate, for example, IEEE 802.11a can support 54Mbps peak data rate, it only supports indoor and very low mobility, and the full mobility can only be provided by cellular network. That means the current 3G capability is not enough to satisfy the subscriber's future requirement, they must be enhanced.

Based on current 3G standards, 3GPP and 3GPP2 has initiated research on enhancement and evolution for WCDMA [4] and CDMA2000 [5] respectively. As a result, in 3GPP, HSDPA has been proposed for WCDMA to provide high data rate service, and a series of new techniques are adopted to improve the data transmission capability, such as MIMO, AMC, HARQ and fast cell selection [4]. Based on these techniques, the peak data rate can be improved to 10Mbps. The OFDM suitability for HSDPA has also been researched [6]. In 3GPP2, EV DO and EV DV have been proposed to enhance the data transmission capability of CDMA2000, and similar techniques as that in WCDMA HSDPA are adopted. By single carrier of 1.25MHz, EV DO can provide 2.4Mbps peak data rate in downlink and 153.6kbps in uplink, while EV DV can provide 2Mbps in downlink by single carrier.

On B3G, many Universities, operators and manufactures have started their work. One well-known scheme is VSF-OFCDM developed by NTT DoCoMo, the field demonstration has succeeded and the peak data rate in downlink is 100Mbps. Chinese government has also started FuTURE [7] project on B3G research, the target system is required to support large coverage, hot spot coverage, and the spectrum efficiency is 1.5~2.5bps/Hz, and the peak data rate is 30~50Mbps.

From the current status of 3G and B3G, the mobile high data rate service should be provided by 3G and its enhanced or evolution system before B3G system is available. Obviously, the 2Mbps transmission capability of TD-SCDMA as an independent 3G standard is not enough. It's very necessary to enhance the data transmission capability of TD-SCDMA and provide comparative peak data rate as that of HSDPA and CDMA2000 EV DO。

## III. PATH FOR ENHANCEMENT AND EVOLUTION OF TD-SCDMA

The target of the enhancement and evolution of TD-SCDMA is to improve the system capacity and spectrum efficiency, and the capability to transmit higher data rate service with higher mobility. For speech service, the target is to improve the user number admitted into the system, and the coverage radius, decrease the dropping and blocking ratio. For data service, it is to improve the peak data rate, the system throughput and the coverage radius, decrease the service delay.

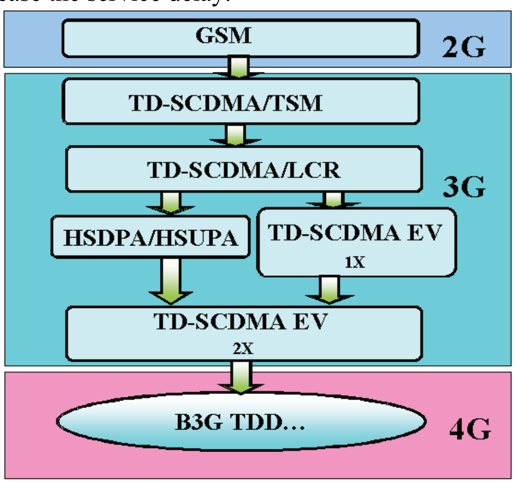


Fig 2 Evolution path for TD-SCDMA

On the other hand, a large amount of money is required to build a new cellular system. The basic rule for the system evolution is smooth evolution, which is to make full use of the current infrastructure, do minimum modification, obtain maximum system performance enhancement, protect the current investment and obtain the largest benefit. So the basic rule for the evolution and enhancement of TD-SCDMA is to improve its coverage capability, data transmission capability, and mobility supporting capability. Meanwhile, the design of B3G TDD system should take into account the features of TD-SCDMA, and make the B3G TDD system compatible to TD-SCDMA system.

Considering the current status of TD-SCDMA and the future requirement, the path for the enhancement and evolution can be summarized as Fig 2.The enhancement and evolution of TD-SCDMA can be classified as 5 phases: TSM, LCR, HDR, B3G TDD and after 4G.

## *A. TSM*

TSM（TD-SCDMA System for Mobile） [8] is the first phase of TD-SCDMA, in which the core network is compatible to that of GSM/GPRS, and it is a technical specification of CWTS. TSM is based on the GSM network, which keeps most part of the TD-SCDMA network the same as that of GSM network (include the BSC, MSC, etc.), but the air interface is changed to TD-SCDMA, which is almost the same as that of LCR. Thus TD-SCDMA can obtain much higher spectrum efficiency and provide much higher data rate service than that of GSM. For TSM is based on the matured GSM high layer protocol stack, it can be developed rapidly, and its network can be setup as soon as possible. Also for this reason, TSM is a phase between 2G and 3G, which can't provide all the services required by 3G, but it can make the evolution from 2G to 3G smoothly, and save the time and the investment to develop and deploy a system. TSM is just an optional phase on the way to 3G and B3G. For those operators without GSM network, this phase can be surpassed.

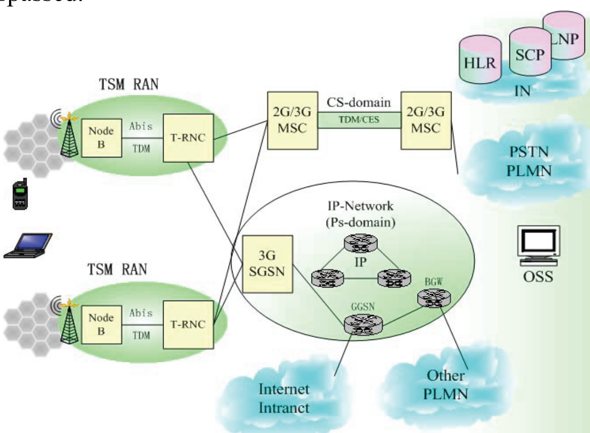


Fig 3 TSM RAN with R99 Core Network (CN)

## *B. LCR*

LCR（Low Chip Rate）[9] is a real 3G system, which can provide all the service required by 3G. As one of IMT-2000 RTT, LCR is accepted by ITU and 3GPP, which adopts the high layer protocol of 3GPP and TD-SCDMA air interface and fulfills all the requirements of ITU.

In this phase, three version of the 3GPP core network can be supported as follow. The TSM and LCR can coexist in the same RAN (not given in our pictures) for they are fully compatible in physical layer.

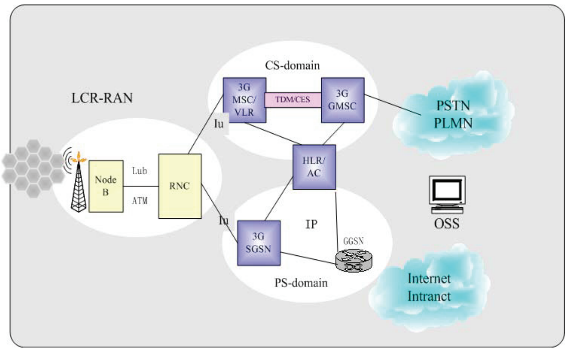


Fig 4 LCR RAN with R99 CN

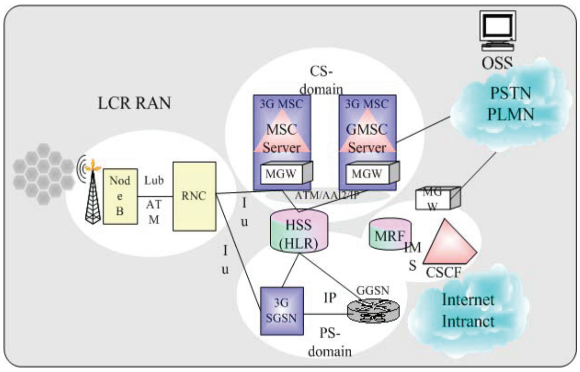


Fig 5 LCR RAN with R4 CN

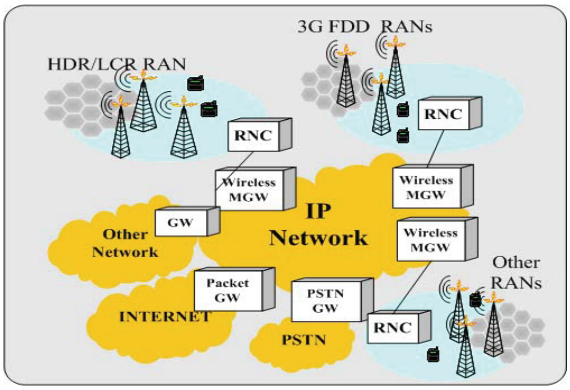


Fig 6 LCR RAN with all IP CN

## *C. HDR*

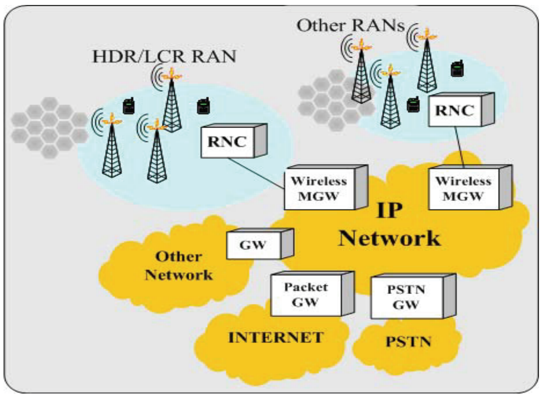


Fig 7 HDR/LCR RAN with IP CN

HDR is the enhancement and evolution phase of TD-SCDMA. Compared to the original TD-SCDMA, HDR can provide much higher transmission and coverage capability. Based on MIMO AMC, HARQ, etc., HDR can provide comparative data transmission capability as that of HSDPA and CDMA2000 EV DO. At this phase, the HDR and LCR can coexist in the same RAN.

### D. B3G TDD

In this phase, the B3G TDD system is started to be deployed, TD-SCDMA is still compatible to it, so the HDR/LCR of TD-SCDMA and B3G TDD system can coexist in the same RAN. To do so, the design of B3G TDD system should take into account the features of TD-SCDMA system, and make the system design compatible to TD-SCDMA.

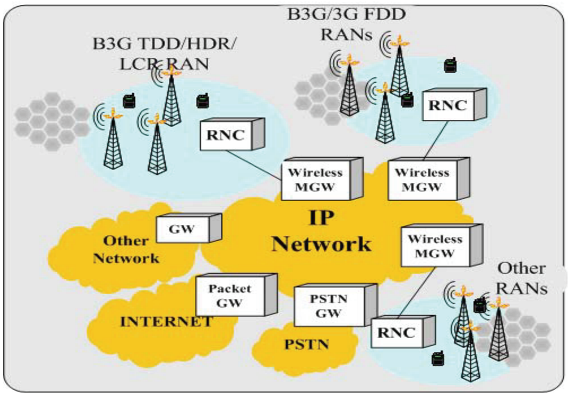


Fig 8 HDR/LCR smoothly evolution to B3G TDD RAN with IP CN

The research on B3G system has been started world widely for a long time. As shown in section II, the smooth evolution is very important. The knowledge on the requirement of TD-SCDMA smooth evolution to B3G TDD can guide the design of B3G TDD.

As an example, the possibility of the smooth evolution from TD-SCDMA to FuTURE B3G TDD [10] system is presented here. The common features of TD-SCDMA and FuTURE B3G TDD make the compatible between them very possible [10]:

1) The same frame length and similar frame structure.
2) Both of them are based on software radio architecture.
3) Both of them adopt the synchronous uplink.
4) Both of them are based on full IP core network.
5) Similar Multiple Access scheme: TDMA, FDMA, CDMA, SDMA.

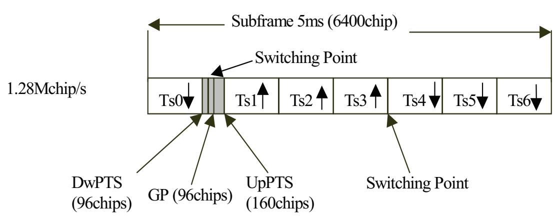


Fig 9 The sub frame structure of TD-SCDMA

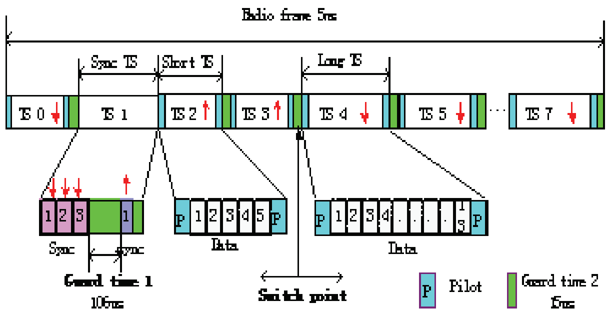

Fig 10 Frame structure of FuTURE B3G TDD

On the other hand, more consideration for smooth evolution should be taken into account:

1) *Physical Layer.*

Keep the frame period the same, and keep the public time slot the same, for example the synchronization time slots, Reserved a number of subcarriers in OFDMA for the bearer of TD-SCDMA signal and adopt similar techniques.

2) *High Layer Protocol keeps compatible.*

The High layer protocol of TD-SCDMA is almost the same as that of WCDMA, so the design of B3G TDD should take this into account, and make its high layer protocol compatible to that of WCDMA or TD-SCDMA. Then the smooth evolution in high layer protocol is guaranteed.

### E. After 4G…

In this phase, TD-SCDMA coexists with 4G，5G and other system. For the change of different generation mobile system is very fast, new system and standard may appear every 10 years, while the investment on a mobile network is very huge, a current mobile system will not disappear soon after a new generation is deployed, but coexists with them for a long time, cooperates and competes each other. That is to say, even 4G or 5G mobile system has appeared, TD-SCDMA will still coexist with them and provide service for a quite long time.

The Technique and Scheme for the enhancement and evolution of TD-SCDMA

Based on the research, the research on the enhancement and evolution of TD-SCDMA can be carried out in the following aspects.

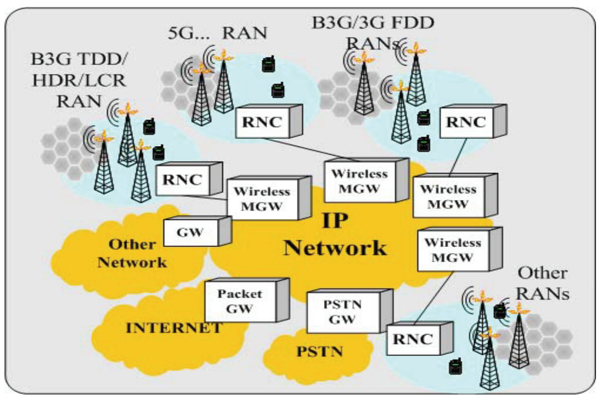


Fig 11 the network Architecture after 4G

## IV. THE TECHNIQUE AND SCHEME FOR THE ENHANCEMENT AND EVOLUTION OF TD-SCDMA

Based on the research, the research on the enhancement and evolution of TD-SCDMA can be carried out in the following aspects.

### A. Generalized Distributed Antenna Arrays (GDAA) combined with dynamical channel allocation.

Compared to WCDMA and CDMA2000, the capacity of TD-SCDMA is mainly limited by the inter-cell interference, but not by the intra-cell interference for the smart antenna and joint detection. If the inter-cell interference can be decreased, then the system capacity can be improved. In [11] [12], the distributed antenna is used to improve the coverage in the indoor scenario and mitigate the fast fading. In this paper, the generalized distributed antenna array system (GDAA) [13] is proposed to improve the coverage and system performance of TD-SCDMA. With GDAA as Fig , the whole cell can be divided into several sub-cells, which is covered by an independent antenna array, and thus the transmit power required by the same receiver sensitivity and the inter-cell interference can be decreased, the capacity and the transmit efficiency can be improved. Meanwhile, the user only synchronize to the antenna array which is connected to, the coverage limited by the guard period length can be loosened. Dynamical channel allocation can be combined with BAA to improve the system performance and the data transmission capability further. By DCA, the SDMA can be implemented in TD-SCDMA, and the same codes can be reused in the same cell. Thus the radio resource units provided may be doubled and the system capacity can be improved.

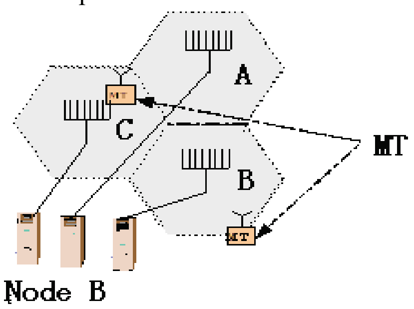


Fig 12 Three conventional cells

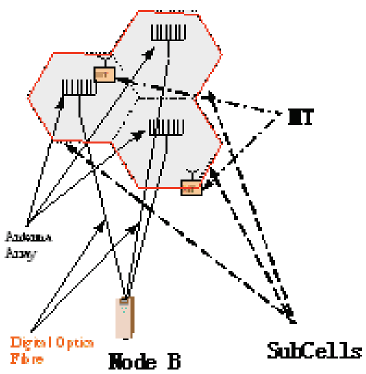


Fig 13 one cell of GDAA

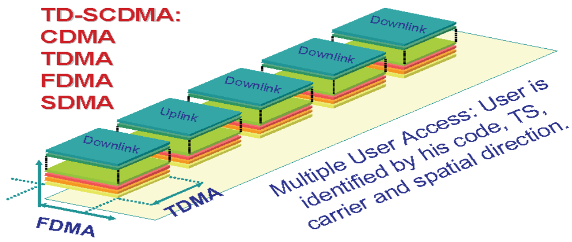


Fig 14 Flexible Radio resource structure of TD-SCDMA

### B. Enhancement and Improvement on Joint Detection

The Joint detection [14] is one of the key techniques of TD-SCDMA, and it can eliminate the MAI and ISI. The enhancement and improvement on joint detection can provide the basis for the further performance improvement. When SDMA is implemented, in which the same codes can be reused in the same cell, the interference still exists between different users, which use the same codes, for the smart antenna can't eliminate the side lobe perfectly. If the joint detection can take into account this kind of interference and eliminate it, the SDMA can obtain higher efficiency. And if the joint detection can eliminate the inter-cell interference, the system capacity and spectrum efficiency of course will be improved greatly. So the enhancement and improvement on the joint detection has much potential to improve the system performance.

### C. Joint Transmission (JT).

JT is a downlink transmission technique of TDD based on the uplink reception [15] [16]. In TDD system, when the interval between the uplink reception and downlink transmission is shorter than the coherent time of the channel, the channel impulse responses of uplink and downlink is highly correlated. Based on the uplink joint detection information, with the spreading codes information known at the Node B, the transmitted signals are preprocessed at the Node B and then transmitted out to the MTs. Then MTs can recover the data from the received signal by simple despreading with the user spreading codes without channel estimation and joint detection. Thus the receiver of the MT can be simplified, no training sequence in downlink is needed theoretically, and the transmission efficiency can be improved greatly.

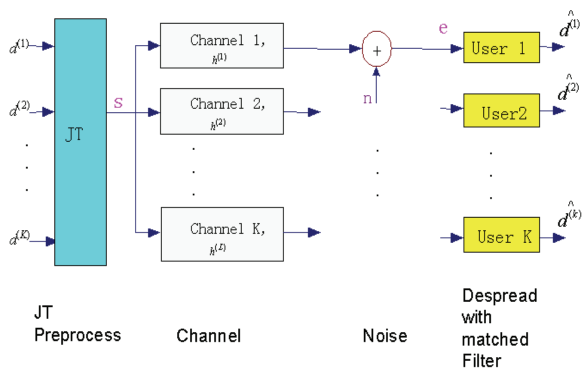


Fig 15 The block of JT

$d^{(1)},...,d^{(k)}$ is the user data, $S$ is the sum of the transmitted signal after the preprocessing of the JD based on the uplink channel estimation and joint detection information. The model of the transmitted signal is:

$$\mathbf{e} = \mathbf{Hs} + n \qquad (1)$$

The signal detection model is:

$$\hat{\mathbf{d}} = \mathbf{C}^{H}\mathbf{e} = \mathbf{C}^{H}\mathbf{Hs} \qquad (2)$$

$\mathbf{C}^{H}$ is the spreading code matrix.

### D. Link Adaptation (LA) and opportunistic communication

The HSDPA and EV DO schemes have proved that link adaptation and multiuser scheduling can improve the peak data rate and the system throughput greatly. So it is very important to investigate their effect on HDR of TD-SCDMA. In HSDPA or EV DO, only one user is served in one Time Slot, different user is served by TDM; The multiuser scheduling take into account the user fairness and the transmission efficiency, and the multiuser diversity can be exploited, so the system spectrum efficiency can be improved. AMC can adapt to the change of the user channel, and select proper modulation and coding scheme to make full use of the channel and the transmission power, and then improves the user throughput, power efficiency and spectrum efficiency. HARQ can guarantee the BER of user service and improve the efficiency of packet repeat, and multiuser scheduling can exploit the multiuser diversity gain. So based on AMC, HARQ and multiuser scheduling, the data transmission capability of TD-SCDMA can be enhanced.

### E. The enhancement from MIMO

The research in [17] [18] [19] shows that MIMO has big potential to improve the system performance and the transmission capability of wireless communication, especially when the fading among the different antennas at the transmitter and the receiver are independent, the system capacity is proportional to the minimum antenna number of the transmitter and the receiver with the same condition as the conventional system. So the research on the MIMO for TD-SCDMA is very promising. As a TDD system, the channel reciprocity can be exploited to improve the MIMO performance on spatial multiplexing gain and diversity gain. Fig  is the common MIMO system for TD-SCDMA.

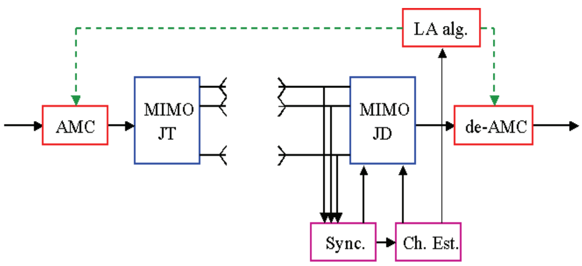


Fig 16 Common MIMO system for TD-SCDMA

### F. Higher spreading factor and chip rate

The Potential benefits of higher chip rate include system gains from trunking efficiency, link level gains from the ability to better resolve channel paths, the ability to support more accurate location services, higher possible peak bit rates and cell throughputs and an improved ability to reject narrowband interferers. In [20], the benefit from the 7.68Mcps for UTRA TDD is investigated in detail in 3GPP. Thus with higher spreading factor and chip rate, for example SF=32 and chip rate is 2.56Mbps, more spreading processing gain, multipath resolution and interference elimination can be obtained for TD-SCDMA, and better system performance is expected.

## V. HIGH DATA RATE PROPOSAL FOR TD-SCDMA

In this section, a High data Rate (HDR) proposal based on MIMO, AMC, HARQ and multiuser scheduling for TD-SCDMA is presented. It is expected to provide the comparative peak data rate as that of HSDPA and EV DO.

### A. Time slot allocation

Fig  is the time slot allocation for HDR in downlink. And similar time slot allocation scheme can be adopted in uplink of HDR. For the basic subframe length of TD-SCDMA system is 5ms, the basic scheduling period is designed as 5ms. TS1 is used for MT to report the channel state information (CSI) and the other signaling. TS2~TS6 is combined together for data transmission in a TTI (5ms) and TS0 is used for downlink signaling. Every 5ms, only one user in a cell is served, thus the throughput of the user can be improved greatly. The MCS from [4] and turbo coding are adopted in our HDR scheme.

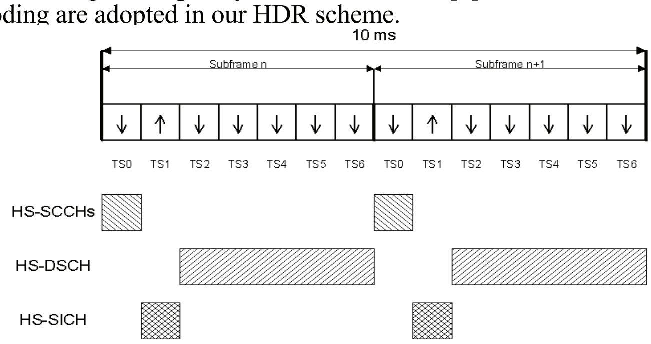


Fig 17 timeslot allocation for downlink HDR of TD-SCDMA

### B. MIMO Eigen mode Transmission

As a TDD system, TD-SCDMA can exploit the channel reciprocity to exploit more spatial multiplexing gain and diversity gain. In this proposal, MIMO Eigen beamforming [21] [22] is adopted, and every Eigen mode is used to transmit data. After channel coding, interleaving and AMC, the separate data symbol for different Eigen mode is spread and scrambled, and then precoded by unitary matrix $\mathbf{V}$ resulting from SVD of the spatial correlation matrix of MIMO channel impulse response. The singular Value decomposition of spatial correlation matrix is presented as $\mathbf{R}_{R_M \times T_M} = \mathbf{USV}^{H}$. At the reception, the received signal vector is multiplying the unitary matrix $\mathbf{U}^{H}$ to separate out the signals transmitted on different

Eigen mode sub-channel. In every Eigen mode channel, the data symbols are detected out by joint detection and the MAI is eliminated. Then the AMC is decoded to form the data stream. The theoretical block of the transmission and reception is as Fig . The block of the simple equivalent Eigen mode channels is as Fig .

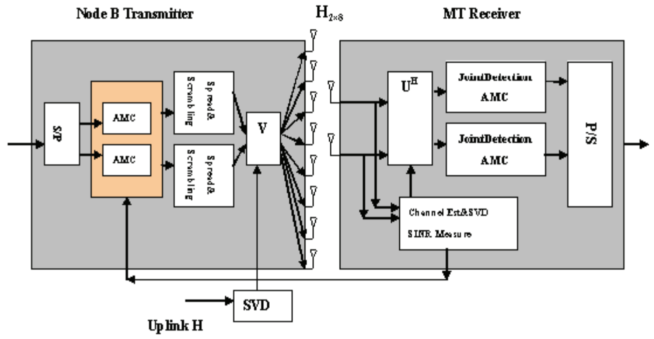


Fig 18 Theoretical Block of the MIMO Eigen mode transmission

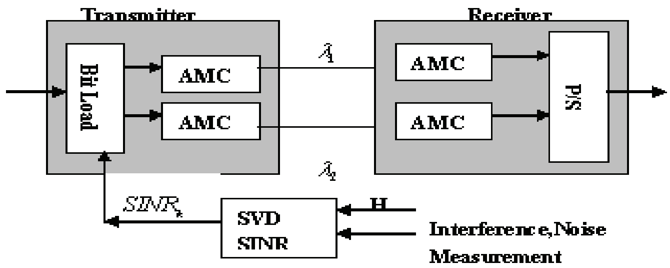


Fig 19 the equivalent Eigen mode sub-channels

By the scheme above, the data rate of different modulation modes are summarized as Table 1. The more antennas configured at the mobile station, the higher peak data rate can be provided.

TABLE 1 PEAK DATA RATE OF HDR WITH MIMO

| MCS | Modulation | code Ratio | Peak Rate |
|---|---|---|---|
| 1 | QPSK | 1/4 | 330kbps |
| 2 | QPSK | 1/2 | 660kbps |
| 3 | QPSK | 3/4 | 990kbps |
| 4 | 16QAM | 1/2 | 1.32Mbps |
| 5 | 16QAM | 3/4 | 1.98Mbps |
| 6 | 64QAM | 3/4 | 3.96Mbps |

## *C. Fast Cell Selection (FCS)*

In HSDPA, no handover is considered. The cell site is selected only when the user is scheduled to transmit packet data in next TTI. This procedure is named as Fast Cell Selection (FCS). By FCS, the best cell serves the UE in the downlink. FCS is adopted in our HDR scheme, but the FCS is based on downlink synchronization channel measurement, etc.

## *D. Link adaptation*

The process of modifying the transmission parameters to compensate for the variations in channel conditions is known as link adaptation. Besides power control, another technique that falls under this category of link adaptation is adaptive modulation and coding (AMC). The principle of AMC is to change the modulation and coding scheme according to variations in the Channel Quality Indicator (CQI), subject to system restrictions. The CQI can be estimated or feedbacked from the receiver. The main benefits of AMC are:

a) Higher data rates are available for users in favorable positions which in turn increase the average throughput of the cell.

b) Reduced interference variation due to link adaptation based on variations in the modulation/coding scheme instead of variations in transmit power.

In this paper, the CQI is defined as the received SINR on every Eigen mode sub-channel. Then it is feedback to the Node B scheduler, which schedule the packets in the user queues according to the metric calculated from individual user throughput and the CQI. After the user has been scheduled, the MCS is selected from Table 1 according to the CQI of each Eigen mode sub-channel, and then MAC frame size is decided for this transmission.

## *E. Packet scheduler*

In this proposal, three improved schedulers can be adopted.

### *1) Max sum capacity scheduler*

The first scheduler is greedy one which is based on the max sum capacity of the user channel. It is similar to max C/I scheduler, but the scheduling metric is not the C/I any more, but the available capacity of one user channel. Based on the waterfilling, the available power of the Node B is allocated to the two Eigen modes, and then the sum capacity is calculated. The user with the maximum sum capacity is scheduled to transmit in the next TTI. This max Capacity scheduler provides maximum system capacity at the expense of fairness, because all the resource may be allocated to a single user which has always the best channel conditions.

$$i = \underset{i}{Max}\left\{C_i\right\} \tag{1}$$

$$C_i = \log_2\left[(1+\frac{P_1^i\lambda_1^i}{I+N_0})(1+\frac{P_2^i\lambda_2^i}{I+N_0})\right] = \log_2\left[\left(SIR_1^i+1\right)\left(SIR_2^i+1\right)\right] \tag{2}$$

$\lambda_1^i$ and $\lambda_2^i$ are the channel gain on eigen mode 1 and eigen mode 2 of user $i$ channel. $P_1^i$ and $P_2^i$ are the power allocated on eigen mode 1 and eigen mode 2 respectively according to the waterfilling, and they meet the following limit:

$$P = P_1^i + P_2^i \tag{3}$$

$P$ is the total available power at the Node B for the downlink best effort transmission.

### *2) Round Robin scheduler*

The Round Robin (RR) scheduler provides a fair sharing of resources (frames) at the expense of system throughput. The user is scheduled to transmit in turn, in which the channel capacity of user is not considered.

### 3) *Proportional Fairness scheduler*

PF scheduler is a tradeoff between the throughput and the fairness. An ideal scheduling interval is assumed and scheduling is performed on a frame by frame basis.

The user with the largest metric value as follow is scheduled to transmit:

$$w_i = \frac{c_i}{\overline{c_i}}, \tag{4}$$

$c_i$ is the user transmission capability, calculated as equation (2). If the user transmits, the average throughput of user $i$ is updated as $\overline{c_i} = \overline{c_i} \cdot (1-\alpha) + c_i \cdot \alpha$ ; Otherwise $\overline{c_i} = \overline{c_i} \cdot (1-\alpha)$ .The forgetting factor $\alpha$ , is a positive constant but less than 1.

## F. *HARQ*

HARQ is adopted to guarantee the reliable data transmission. In this proposal, only a simple ARQ is simulated. When the packet data is retransmitted, the same MCS is selected, and the chase combining is used at the reception. The maximum retransmission is less than 4. If the retransmission exceeds 4, the data packet is dropped. The Retransmission unit is the MAC frame.

## VI. CONCLUSION

For the development of the service and application in mobile communication market, 2Mbps transmission capability of TD-SCDMA is not enough to fulfill the future service in several years, while the B3G system which can provide much higher mobile data rate service is not available until 2010, it is very necessary to investigate the enhancement and evolution of TD-SCDMA. The new techniques make it is possible for TD-SCDMA to provide comparative transmission capability as that of HSDPA and CDMA20001X EV DO. From our research, the enhancement and evolution of TD-SCDMA can be implemented as 5 phases: TSM, LCR, HDR, B3G TDD and after 4G. The research and development on the enhancement and evolution of TD-SCDMA can be started out from GDAA, DCA, MIMO, AMC, and HARQ and so on. Finally, a HDR proposal based on Eigen beamforming for TD-SCDMA is presented. From our design, the HDR scheme can provide comparative peak data rate as that of CDMA2000 1X EV DO and HSDPA, and the peak data rate is 3.96Mbps with 2 antennas configured at the mobile terminal.

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